Operative Techniques in Thoracic and Cardiovascular Surgery

Single-Port Video-Assisted Thoracic Surgery (Uniportal) in the Routine General Thoracic Surgical Practice

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In the last 15 years, video-assisted thoracic surgery (VATS) has rapidly become a milestone in the thoracic surgical armamentarium because it enables the surgeon to offer minimally invasive procedures as part of structured diagnostic and therapeutic pathways of intrathoracic diseases with the same outcomes as after open techniques. In turn, minimal invasiveness is reported to yield reduced postoperative morbidity, duration of hospitalizations, and prompt return to routine daily activities. VATS performed through a single port ("uniportal") pursues the same objectives of standard VATS with even less invasiveness due to the involvement of only 1 intercostal space,[1] thereby potentially resulting in reduced pain and paraesthesia and shortened hospitalization compared with traditional VATS. Currently, there are several indications for uniportal VATS summarized in Table 1. This review focuses on operative uniportal VATS, for which the contraindications are the same as for a conventional VATS approach.[2]

Patient Positioning and Anesthetic Technique

Asepsis is obtained as per routine thoracotomy. Usually, the patient is under general anesthesia with one-lung ventilation and in the lateral decubitus position (Fig. 1). Uniportal VATS for undetermined pleural effusions can also be performed in the awake patient under locoregional anesthesia through single-shot epidural (see below). Once the pleural cavity is entered, the surgical team distributes in a convenient fashion to the target area (Fig. 2A). The assistant—whose main role is to ensure adequate visualization of the intraoperative field—is positioned between the operating surgeon and the scrub nurse[3] (Fig. 2B).

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Surgical Technique

Careful preoperative planning of the procedure is of paramount importance. Imaging studies need to be evaluated to decide the location of the single port.[1]

The usual incision is 2.0- to 2.5-cm-long for operative uniportal VATS but could be shorter (halved) for diagnostic procedures or for sympathectomy (Fig. 3A). Access to the intercostal space is gained by blunt dissection in a fashion similar to chest drain insertion to accommodate the surgeon's index fingerbreadth (Fig. 3B). Care is taken to ensure adequate hemostasis at all times to avoid frequent cleansing of the videothoracoscope lens during the procedure.[1]

With uniportal VATS, the target lesion in the chest cavity is addressed along a craniocaudal approach, which enables the surgeon to obtain thoracoscopic visualization and operate through a single port. Compared with standard VATS with the attendant "baseball diamond" placement of ports to achieve a laterolateral approach, the ensemble of thoracoscope and operative instruments is rotated 90° on the vertical—or sagittal—axis.[1] This principle is maintained in all applications of this procedure and is facilitated by the utilization of articulating devices ("roticulator"), which offer the ability to deploy and rotate their intrathoracic parts so that mutual interference of the operative instruments is avoided and a 360° maneuverability is obtained. Similar to robotic arms, articulating

Table 1 Indications for Uniportal VATS

Biopsy of parietal pleura (ie, undetermined effusions)
Pleural abrasion or pleurectomy
Resection of blebs/bullae
Resection of peripheral (ie, outer third) pulmonary nodules
Wedge biopsy for diagnosis of interstitial lung disease
Mediastinal lymph node biopsy and removal
Thoracic sympathectomy
Pericardial window
Dissection of intrathoracic component of extrathoracic masses
Trauma

1522-2942/09/$-see front matter
doi:10.1053/j.optechstcvs.2009.08.002

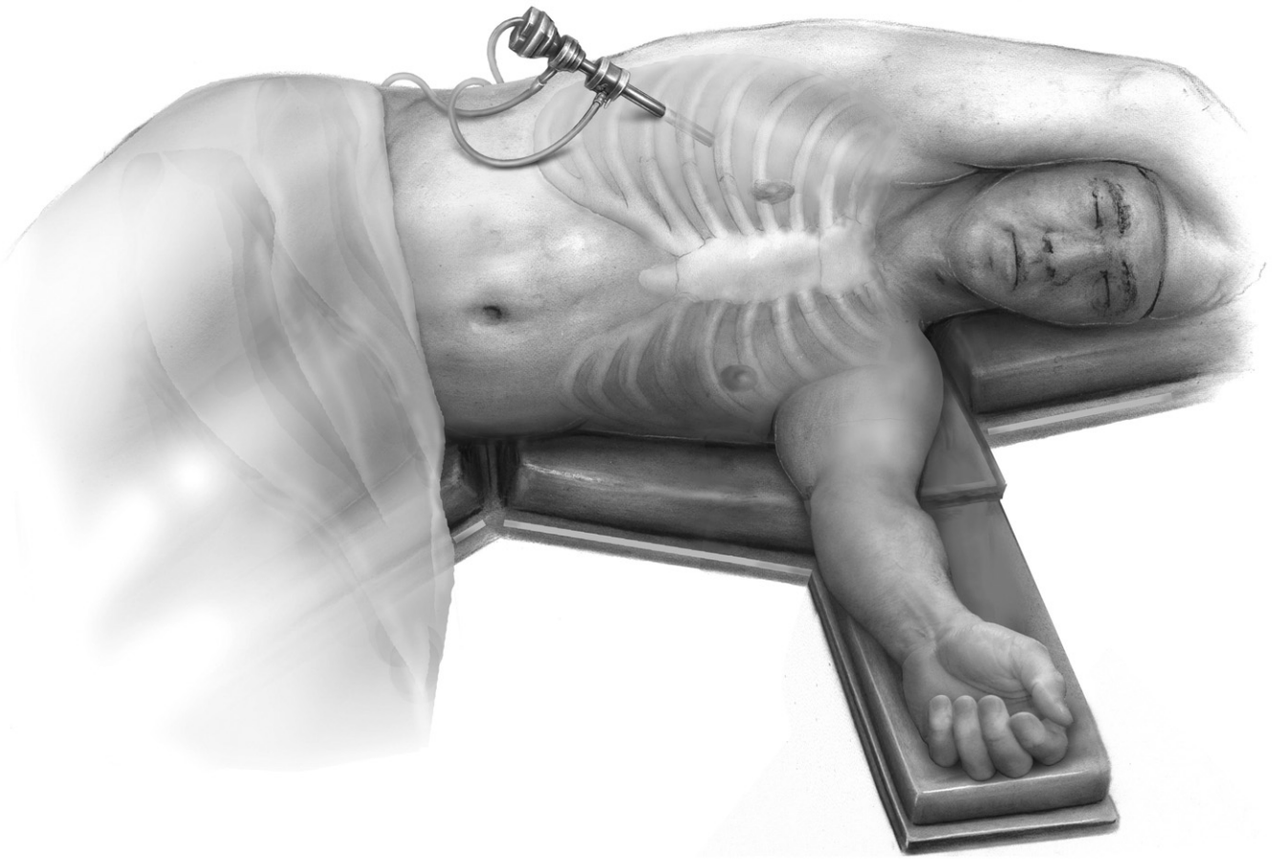


Figure 1 Patient's positioning for uniportal VATS.

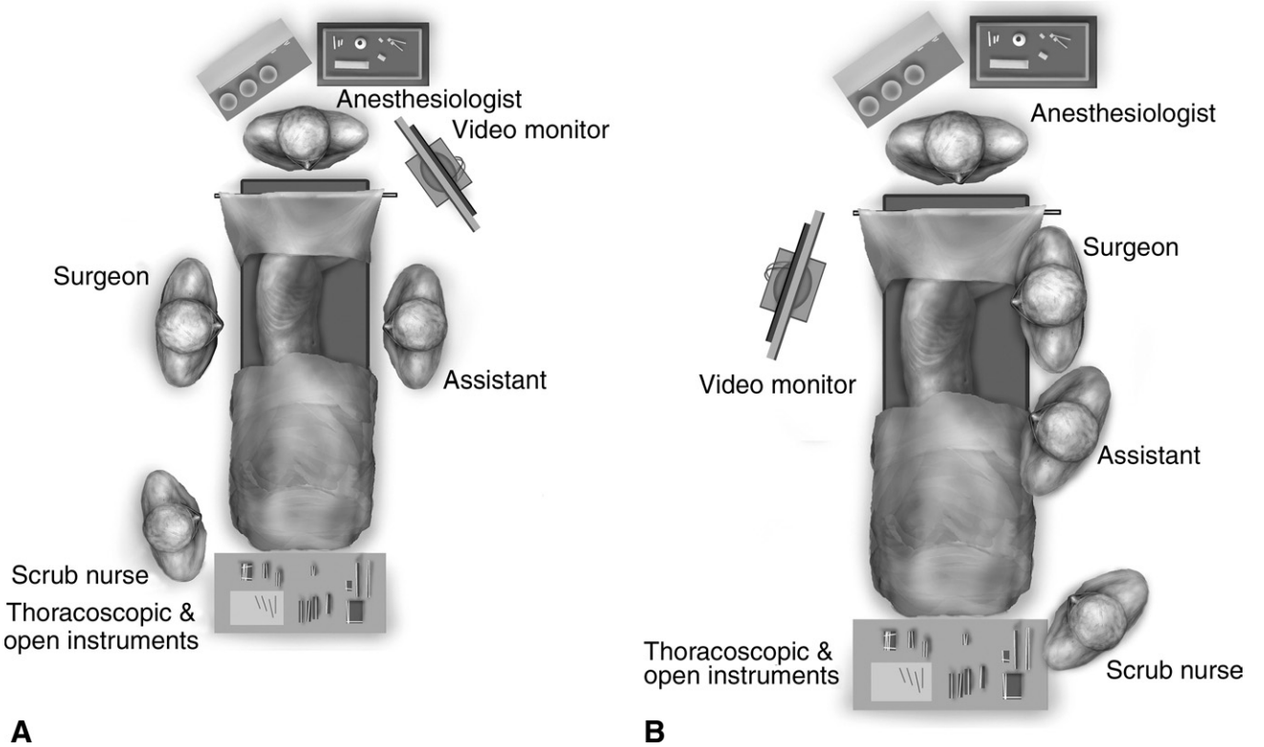


Figure 2 Distribution of the members of the surgical team during uniportal VATS (see text).

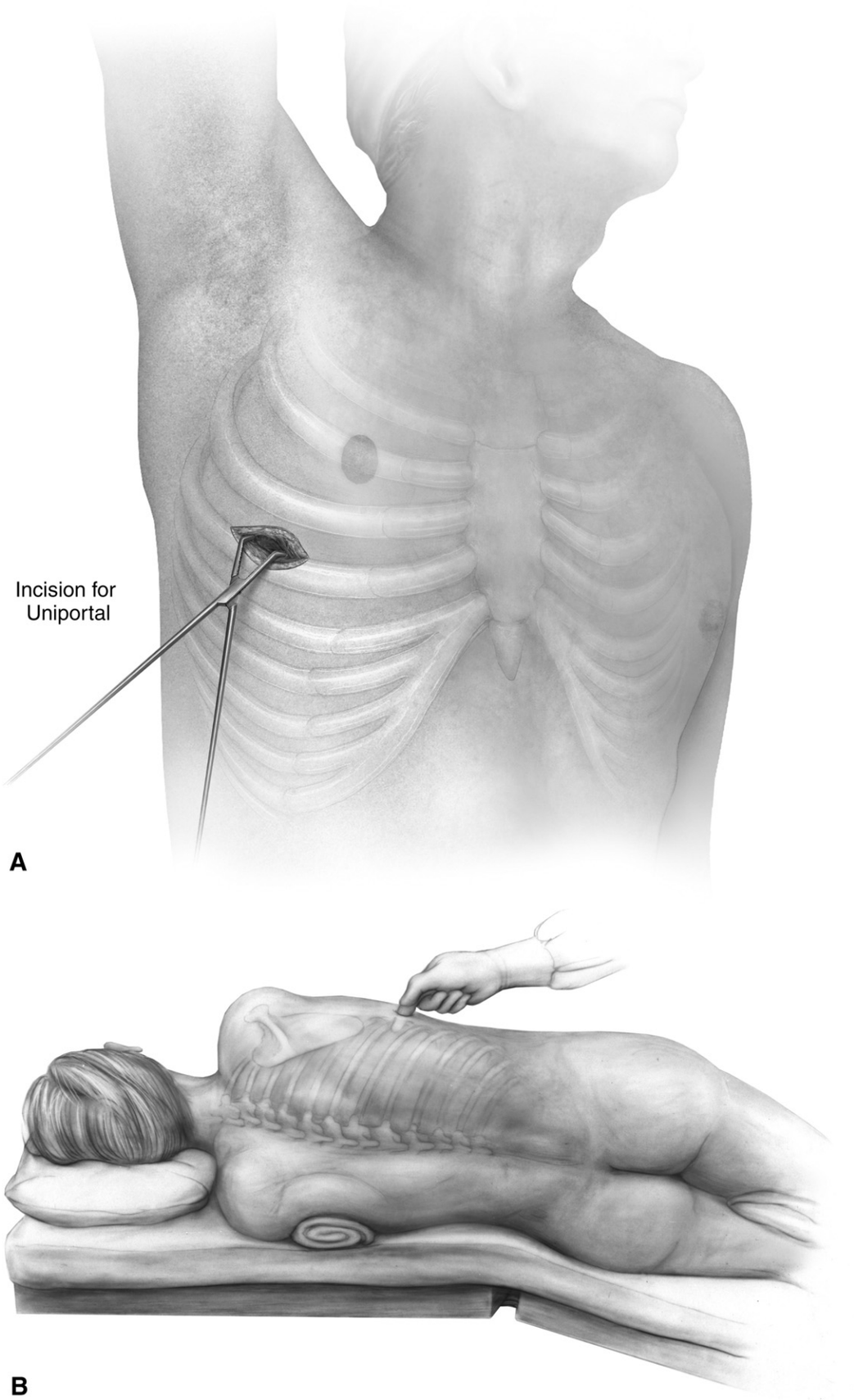


Figure 3 (A) Typical incision measuring 2-2.5 cm, usually accommodating 1 surgeon's fingerbreadth (B).

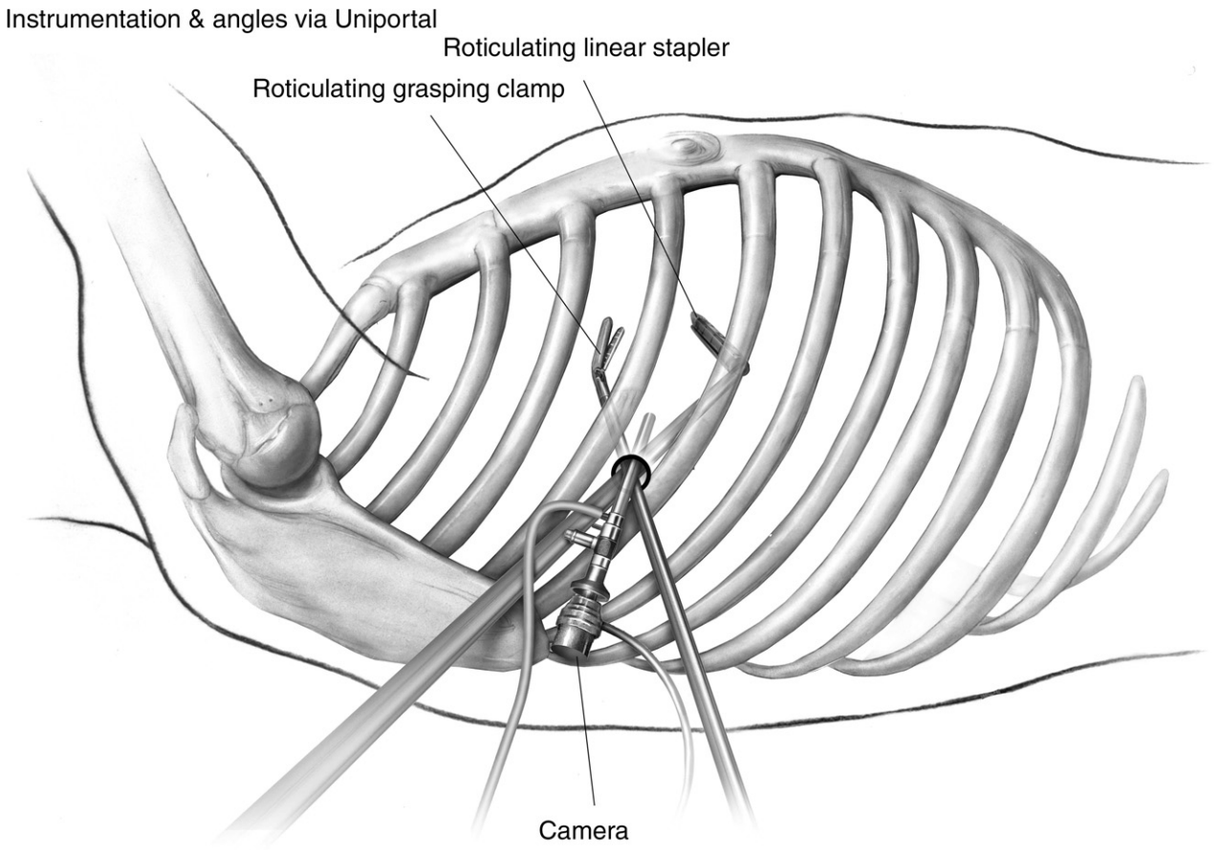


Figure 4 Initial positioning of instrumentation for uniportal VATS wedge resection of the lung.

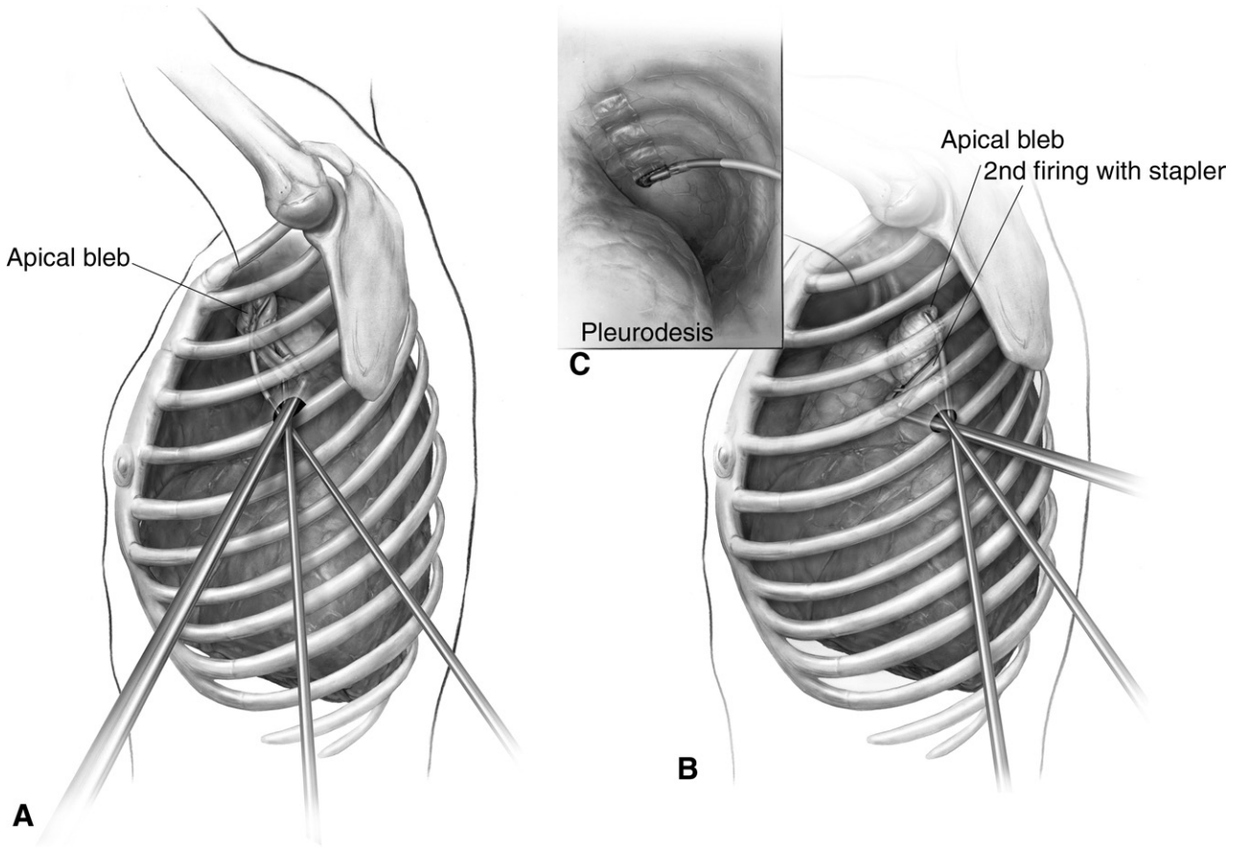


Figure 5 Intraoperative view of sequence leading to uniportal VATS apical bleb resection with initial instrument positioning (A) and subsequent completion of parenchymal stapling (B). (C) Schematic of pleurodesis obtained with pleural abrasion through a scratchpad mounted on an articulating endograsper (see text).

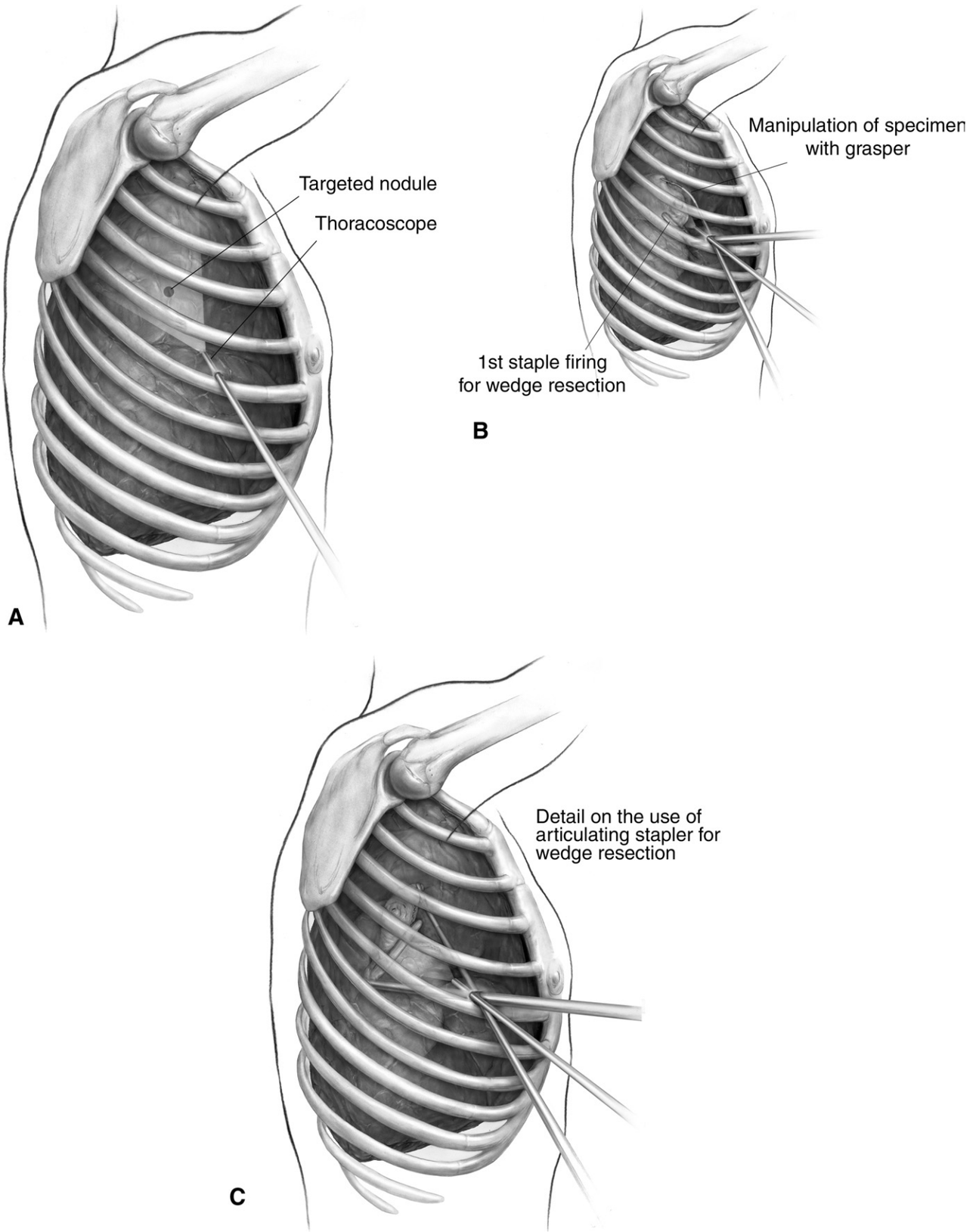
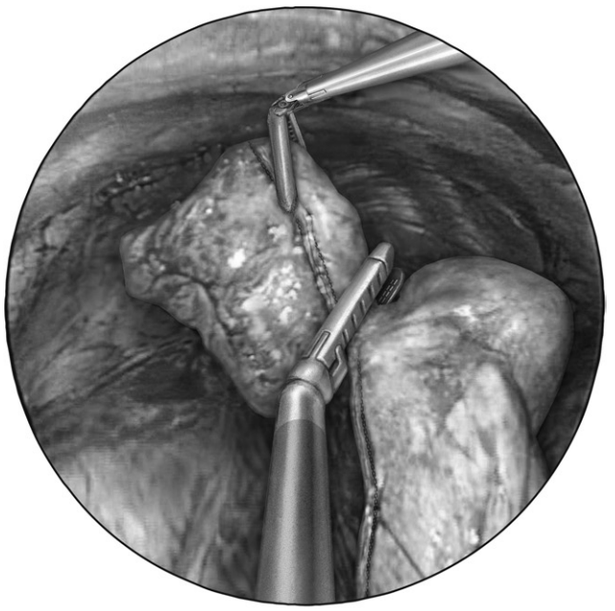
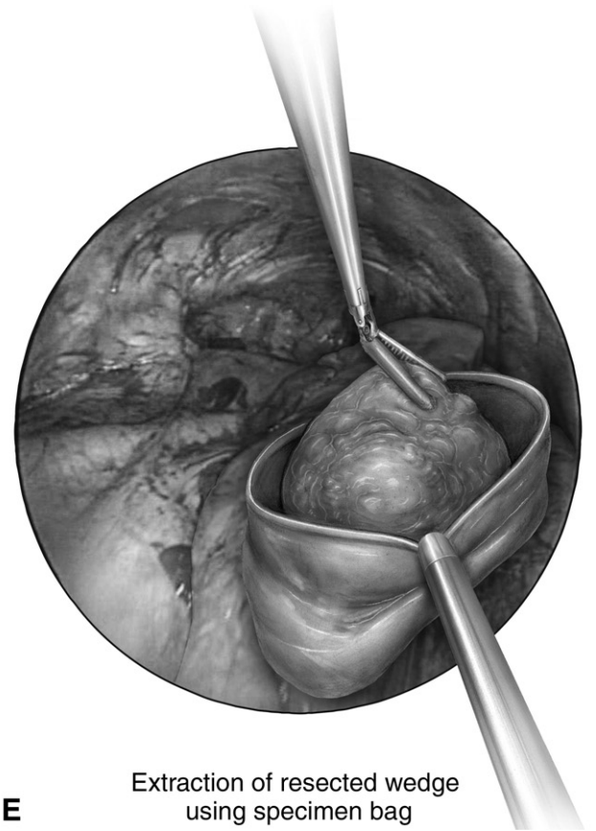


Figure 6 (A) Example of positioning of the videothoracoscope relative to target nodule in the lung (see text). Details on the use of articulating grasping (B) and stapling (C) instrumentation for uniportal VATS wedge resection (D) and subsequent extraction of the specimen with an endobag (E).



D Completion of wedge resection



E Extraction of resected wedge using specimen bag

Figure 6 *(Continued)*

instruments may transfer a significant degree of the human manual dexterity inside the chest—in this case through only 1 VATS incision—without impairing either visualization or operative ability. An additional technical principle for this technique entails paying attention at ensuring a sufficient distance between the port site and the target area to prevent thoracoscope instruments' interference.[1]

Location of the Incision

The placement of the incision is crucial to success of the procedure. For the majority of target lesions in the chest, the selected intercostal space is between the fourth and the sixth. Longitudinally, the midscapular line represents a fundamental anatomical reference in positioning the trocar incision.[1,4] Usually, posteriorly located lesions are approached through incisions located anterior to the midscapular line—generally along the midaxillary line. The intercostal space (as a rule, 4 to 6) is selected based on the lobe on which the target lesion is situated. When the middle lobe and the lobar anterior segments need to be addressed, an incision along or even slightly (1 cm) posterior to the midscapular line is chosen. This incision will be used for chest drain placement at the end of the procedure. In particular, to facilitate placement of drains through incisions located posterior to the mid-scapular line, a supporting roll is used alongside the patient spine to avoid kinking and to facilitate a 15 to 20° recumbent position.

Instruments

The operative instruments and the videothoracoscope are inserted through the same incision, as an ensemble or sequentially, by taking complete advantage of the laterality of the intercostal entry site. The intrathoracic placement of the fulcrum of the articulating instruments ("roticulator"; US Surgical, Norwalk, CT) prevents undue leverage on the intercostal bundle and allows for full adaptation to the dome-shaped, curvilinear, and confined thoracoscopic space.[1] As a rule, the videothoracoscope is situated between the operative instruments, but their position may be frequently changed during the procedure[1,4] (Fig. 4).

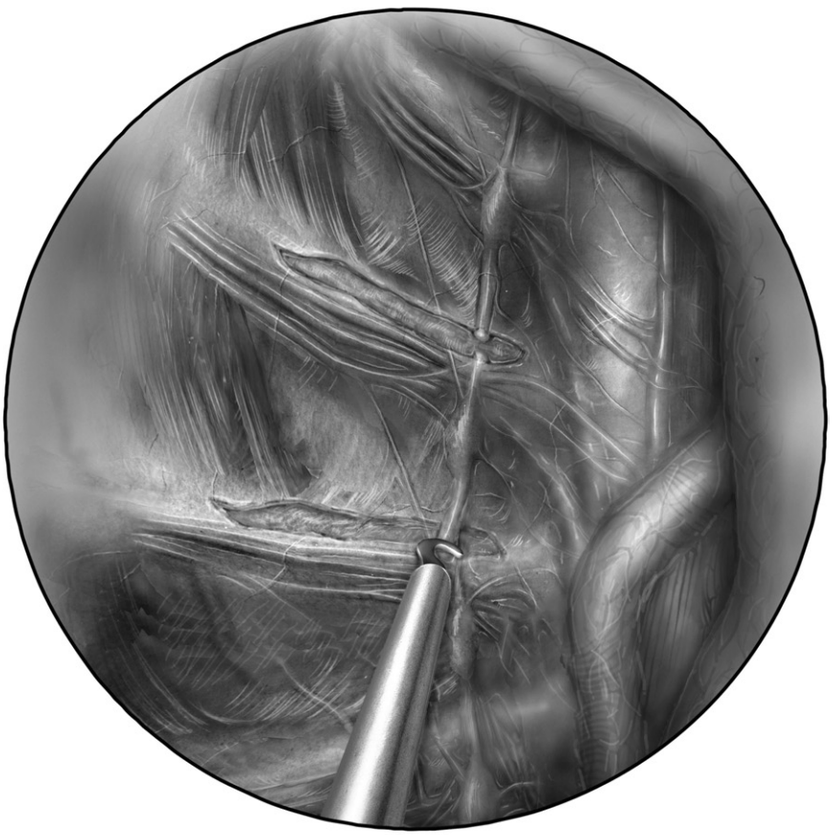
For intrathoracic visualization, a 5-mm, 0° or 30° videothoracoscope is used.[1,4] For sympathectomy or sympathicotomy, a 2.7-mm thoracoscope can be utilized. Lung suspension along the sagittal plane is performed with 5-mm roticulating endoscopic graspers. Likewise, roticulating endostaplers are used to divide the parenchyma during diagnostic or therapeutic uniportal procedures. As a rule, 3.5-mm, 45- or 60-mm-long, blue cartridges are utilized and the anvil is articulated outside the chest. The endostapler is handled and inserted in a way similar to the "mediastinoscope slid under the pretracheal fascia." Articulating endograspers and endostaplers are inserted parallel to the videothoracoscope, taking care to retract the 5-mm trocar along the stem of the thoracoscope to increase the available maneuvering space.

Other standard thoracoscopic instruments should be made available for use along with a long and thin Roberts' clamp. In addition, a thoracotomy tray should be available at all times in the theater.

Uniportal VATS for Pneumothorax, Wedge Biopsy, and Pulmonary Nodules

If the patient to be treated presents with a chest drain in place, the same incision should be used to perform the pro-

A Right sympathectomy begun over 2nd rib



B Right sympathectomy completed over 3rd rib

Figure 7 Details of uniportal VATS right sympathectomy begun over the second rib (A) and completed over the third rib (B).

cedure. When the target area on the lung is easily identified, lung manipulation is reduced to a minimum but enough to inspect the lung for other emphysematous changes.[5] The endograsper is positioned on the bleb/bullae and the articulating arm is deployed to fully expose the diseased area[1,5] (Fig. 5A). The jaws of the endostapler are opened inside the chest and positioned, facing upward, just caudal to the bleb/bullae to be removed[1,5] (Fig. 5B). To this purpose, the endograsper has to "accommodate" the parenchymal area inside the endostapler jaws, which can then be gently pushed into position before firing.[1,5] The endostapler is fired and the endograsper repositioned more distally onto the remaining lung to be resected. As a rule, up to 3 firings are usually needed to complete the procedure. The specimen is then extracted through the same incision using an endobag or directly with a long Roberts' clamp.[1,5]

Pleural abrasion can be performed by mounting on a Roberts' clamp or on the same roticulating endograsper an electrocautery scratchpad cut down to fit the port incision.[5] On deployment of the articulating arm of the endograsper, the scratchpad will conveniently adapt to the convexity of the inner chest cavity to start an abrasion (Fig. 5C). Alternatively, an apical pleurectomy can also be performed with the aid of an endo kittner (endopeanut).[5]

When the lung is biopsied for the diagnosis of an interstitial parenchymal process, the selected target area is usually chosen based on preoperative workup imaging.[6] The lung is suspended by an endograsper and "presented" to the open endostapler jaws, which are advanced as needed. The stapler is closed and fired and the pulmonary edges are checked for air leaks and bleeding. This sequence is repeated as needed to remove the diseased parenchyma.[6]

Using the same technique,[1,6] visible peripheral nodules measuring up to 2 cm in diameter can be easily addressed (Fig. 6A) and removed through an endobag (Fig. 6B-D). Virtually all peripheral nodules in the lung can be resected by a uniportal VATS approach.[7] Coupled with mediastinal nodal sampling, the uniportal VATS wedge resection of a pulmonary nodule on adequate margins is feasible in selected patients with borderline cardiopulmonary function or single metastatic deposits from extrathoracic neoplasms.[1,8] As with traditional 3-port VATS, palpation of the lung is hindered. However, the use of articulating endograspers and gentle traction enables the surgeon to mobilize for finger palpation areas not limited to the lung underlying the port incision.

Uniportal VATS Mediastinal Nodal Biopsy and Pericardial Window

As to the location of the incision and the insertion of the uniportal operative ensemble, the same principles apply.[8] However, for masses in the anterior mediastinal compartment or to create a pericardial window,[9] an alternative approach could be with the patient in the supine position while the port is located along the posterior axillary line with the operated side elevated (45°) by an axillary roll. Once the targeted nodal station is identified, it is exposed by dividing the overlying mediastinal pleural using a roticulating grasper and endoscissors.[8] Moreover, an endopeanut is utilized to dissect the mediastinal fat around the node, which is then biopsied in a fashion similar to standard mediastinoscopy.[8] Alternatively, the entire lymph node is grasped and suspended while an endoclip is fired at the base of the vascular pedicle to secure hemostasis.[8]

As to the pericardial window, the side of the uniportal approach is selected based on the most prominent pericardial bulging as indicated by preoperative ultrasound and computed tomographic scan evidence.[9] The incision is placed in the fifth interspace along the axillary line with the patient supine or with the selected hemithorax elevated (45°) by an axillary roll. For this procedure, a 2.7- or 5-mm videothoracoscope is inserted and the pleural cavity is inspected. An area of the pericardium anterior to the phrenic nerve is identified and a limited amount of fluid is evacuated though a pericardiocenthesis under endoscopic visualization through a long spinal needle inserted along the videothoracoscope to decompress the pericardium and to facilitate subsequent grasping. In my experience, the creation of a window anterior to the phrenic nerve is usually sufficient to ensure adequate pericardial drainage. To this purpose, the parietal pericardium is lifted cranially with thin forceps or endograspers and opened with endoscissors inserted parallel to the videothoracoscope. The window is completed by circumferential incisions of the pericardium. If needed, additional diagnostic and/or therapeutic tasks can be accomplished through the single port. A chest tube inserted through the same incision is left at the end of the procedure.[9]

Uniportal VATS for Sympathectomy, Trauma, and Special Situations

The patient is sequentially placed on both semilateral decubitus positions. The right side is approached first.[10] The incision is placed at the base of the hairline in the axilla and a long 5-mm trocar is inserted to accommodate the thoracoscope.[10] The trocar sleeve is retracted along the thoracoscope shaft and a diathermy hook is inserted. If adhesions are identified, these are taken down using an endograsper and endoscissors as indicated. Otherwise, the resort to an endograsper is necessary only when the lung is incompletely collapsed to accommodate the thoracoscope, which is pushed onto the lung apex to access the sympathetic chain.[10] Once the desired level of resection is selected and the corresponding ganglia is identified, monopolar cautery is used on a diathermy hook to divide the pleura on the rib. The heel of the diathermy hook is gently pressed against the ganglion and onto the rib down to the periosteum[10] (Fig. 7). Care is taken at not pointing the diathermy toward sizable venous branches, which can be injured by inadvertent current transmission. The nerve stumps are then checked for residual connecting nerve bridges and further applications of the hook are warranted to avoid possible future nerve regeneration.[10] The division of all tissue down to the periosteum is performed laterally (at least 5 cm) to include possible Kuntz's fibers responsible for symptom recurrence.[10]

Uniportal VATS can be utilized in patients with thoracic trauma under stable cardiorespiratory conditions to diagnose

bleeding sources and/or remove foreign bodies.[11] Through the same incision used for the chest drain, a 5-mm thoracoscope may be introduced to explore the cavity and make a decision on whether a more aggressive approach is needed. In the event of a minor bleeder, hemostasis can be achieved by inserting an endoclip applier parallel to the videothoracoscope as well as other vessel sealing instruments. The resort to a fan retractor and an endobabcock grasper (US Surgical) may serve the purpose of removing retained objects hidden in costophrenic recesses.[11]

Uniportal VATS represents a valid addition to the minimally invasive surgical armamentarium when a mass lesion involves the cervicomediastinal area.[12] While 1 surgical team dissects the neck component, the thoracic surgeon, through 1 small, strategically placed incision, can free the intrathoracic part, thus avoiding the thoracotomy-related morbidity.[12] Likewise, uniportal VATS has also been used to dissect the extraforaminal component of a dumbbell neurinoma as a part of a combined approach with the neurosurgeon (unpublished data).

Uniportal VATS for Undetermined Pleural Effusions and Early Empyemas

Recent use of VATS to diagnose pleural effusions through one port dates back to the work of several authors who, since the late 1980s, used the mediastinoscope to obtain histological diagnosis from undetermined effusions.[13] With the advent of thoracoscopy, the use of a single incision to manage pleural effusions became more widespread.[14] In brief, the biopsy forceps is inserted parallel to the videothoracoscope and this ensemble is maneuvered consensually inside the chest cavity. The procedure can be performed under either general or local anesthesia. However, a locoregional analgesia through a single shot of anesthetic agent in the epidural space at the T3-4 level allows a 3-hour pain-free interval for thoracoscopic maneuvering (Video 1; supplementary video is available online at http://www.optechtcs.com). In some circumstances (ie, early empyemas), the videothoracoscope can be used as a dissector to break loculations, thereby permitting a more effective drainage. Preferentially, nodules on the parietal/diaphragmatic pleura should be biopsied. Biopsy of small nodules on the visceral pleura may be complicated by persistent air leaks. Special attention should be used to avoid the intercostal bundles while obtaining a pleural biopsy. Frozen section should be available to confirm sample adequacy and nature. For talc pleurodesis, the stem of the insufflators is inserted inside the chest under direct thoracoscopic view. Perfect hemostasis of the port site is mandatory to avoid wetting the tip of the insufflator. The two crucial areas for talc pleurodesis are the diaphragm and the apex of the chest cavity, which are easily reached through the single-port incision.

Conclusions

The uniportal VATS approach is feasible, safe, and reproducible.[1,4] It is meant to emphasize the clinical acumen of the surgeon in the interpretation of preoperative imaging to determine the best location for the single incision. In fact, compared with traditional VATS, the use of only one port and 5-mm (or smaller) instruments introduced in the chest without trocars may avoid multiple intercostal nerve injury.[4] As a consequence, operative or diagnostic uniportal VATS can be utilized in a substantial proportion of the routine clinical practice because its use may lead to decreased pain and paraesthesia and an attendant reduced hospitalization.[15] The latter is a major factor concurring at offsetting potential additional costs generated by the use of articulating instruments.[16]

As a diagnostic tool, uniportal VATS can be used to obtain histological diagnosis of virtually all pathologic conditions in the chest. It may obviate the need for multiple or more extended incisions to diagnose/treat concomitant intrathoracic lesions and can be planned at the bedside of the intensive care unit patient. As an operative procedure, uniportal VATS seems to present a variety of applications where the intrathoracic target is easily identified. A more reliable, user-friendly preoperative marking of pulmonary nodules as well as the use of flexible videothoracoscopes and the development of smaller instrumentation for parenchymal or vessel sealing will make uniportal VATS even more appealing as a first-line surgical approach to intrathoracic conditions in the future.

Supplementary Data

Supplementary data associated with this article can be found, in the online version, at doi: 10.1053/j.optechstcvs.2009.08.002.

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